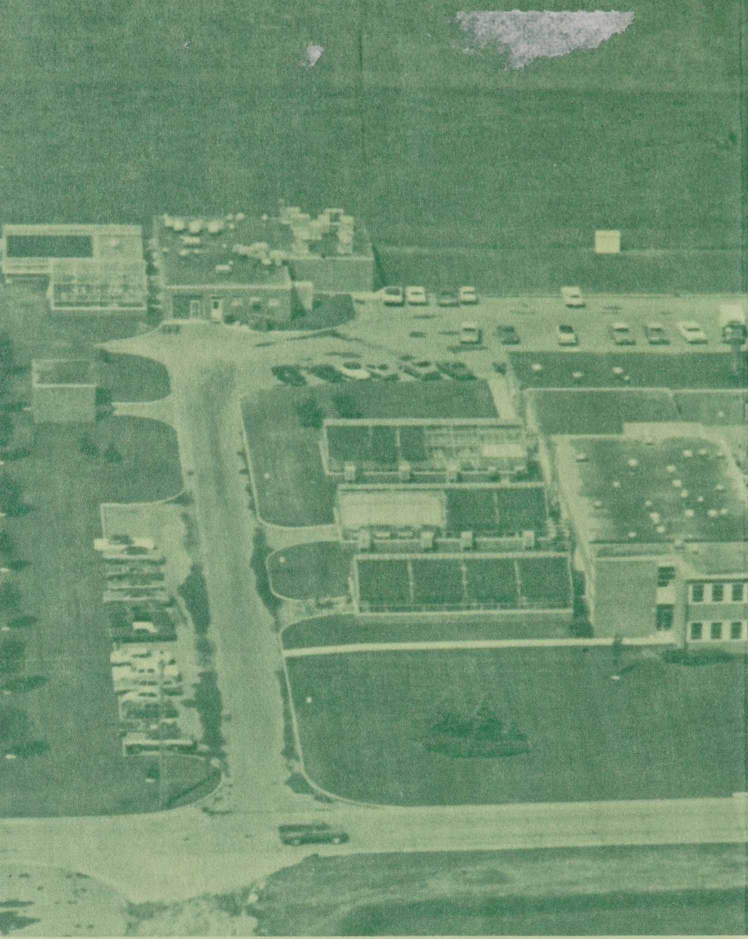
Metabolism and Radiation Research Laboratory

Agricultural Research Service
U. S. Department of Agriculture
Fargo, North Dakota

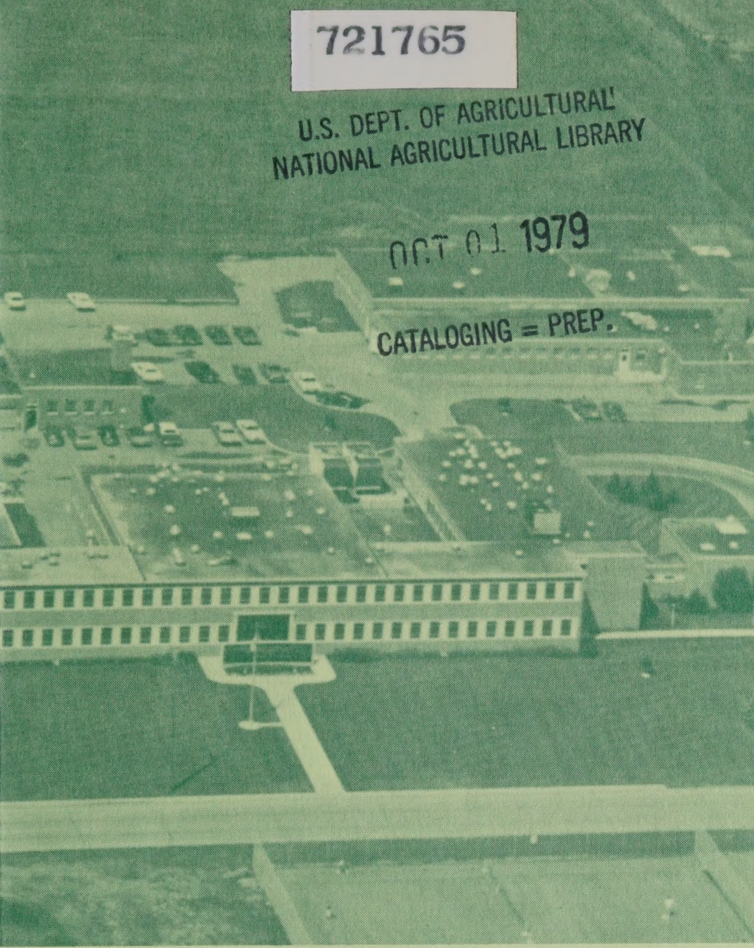


Scientists at the Metabolism and Radiation Research Laboratory, Fargo, N. Dak., conduct research contributing directly to the safe use of pesticides and other agricultural chemicals. They also develop new or improved insect-control techniques that minimize the need for reliance upon broad-spectrum pesticides.

Effective control of insects, weeds, and plant diseases is essential to production of food and fiber in the volume — and meeting the high standards of quality — required by domestic and overseas consumers. Control of these pests must be accomplished in a way that does not endanger the safety of man, his food supply, or the environment.

For the immediate future, chemical pesticides generally will be needed to control pests. But, wherever possible, biological or other alternative measures should be used instead of pesticides. The ultimate goal is to integrate control techniques into safe pest management systems for either eradicating pest populations or suppressing them to economically insignificant levels.

The Laboratory takes its name from two of its major research thrusts: metabolism and radiation. Investigations of animal, plant, and insect life seek a better understanding of metabolism — that process by which living cells assimilate materials and dispose of wastes.



Using atomic radiation for sterilizing techniques in safe control of insects is the other thrust of research.

Metabolism research generally employs chemical compounds that are radioactively labeled for ease in tracing their movement through living systems. With atomic radiation certain insects, when exposed to radiation, are sterilized. When released in nature, these insects mate with native insects but no progeny are produced, thus reducing the total number of insects.

A great deal is known about chemical residues, that part of pesticides and other agricultural chemicals that remain in food products, and the environment after the chemicals' primary jobs have been accomplished. Scientists at the Laboratory want to know the exact physiological and biochemical processes involved in the absorption, trans-location, detoxification, degradation, and elimination of chemicals. They want also to know the metabolic pathways by which pesticides and other agricultural chemicals are taken up, stored, and eliminated by plants and animals. With this knowledge, they can help evaluate the effects on man and the environment of currently used or experimental compounds and formulations.

Similarly, more detailed knowledge of insect genetics and reproductive and life processes may open

or extend opportunities for safe insect control, thus reducing the need for pesticides.

Administered by the Agricultural Research Service, U.S. Department of Agriculture, the Laboratory supports or complements the efforts of Federal, State, and industry scientists throughout the United States. It is located on 10 acres on the campus of North Dakota State University. The site, donated by the State, permits close cooperation among personnel of the Laboratory, the North Dakota Agricultural Experiment Station, and the teaching, research, and extension faculties of the University.

Completed in February 1964, the Laboratory houses about 100 full-time employees, including about 35 senior scientists. Included are entomologists, physiologists, biochemists, chemists, geneticists, radiation biologists, and microbiologists, who use a team approach in solving research problems. In addition, graduate and undergraduate students of the University serve as part-time assistants.

The sophisticated, pioneering research programs of the Laboratory are supported by an array of modern facilities and instruments. Within the Laboratory complex are bioclimatic chambers, greenhouses and controlled environmental chambers for producing a wide variety of plants, rooms for culturing insects, and metabolic and surgical equipment for all species of livestock and poultry. Among the research tools available to the scientists are electron microscopes, a 20,000-curie gamma radiation pool, and such instruments as a mass spectrometer, nuclear magnetic resonance and infrared spectrometers, thin-layer, paper, gas-liquid, and column chromatography, and analytical instruments for radioactivity.

Animal Metabolism

How long do chemical residues remain in the animal body and in what form? What are the capabilities of the animal body to change agricultural chemicals to harmless products? How does the body chemistry accomplish this degradation? What effects do nutrition, reproduction, and environment have on agricultural chemicals in the body?

These are the kinds of questions being answered in studies on the metabolism of agricultural chemicals in animals. Cattle, sheep, swine, and poultry, as well as laboratory animals, are used in these studies.

Experiments are conducted on pesticides, hormones, antibiotics, and other chemicals that may become available to animals as feed contaminants or feed additives. Scientists investigating absorption, translocation, and fate of chemicals introduced into the animal body, are particularly concerned with deposition of harmful residues in milk, meat, or other edible parts, and with residues returned to the environment as a contaminant. Other studies trace alteration, breakdown, and deposition, and the life processes involved, as well as the

effect of chemicals on fermentation processes of the rumen.

Information derived from these research areas aids regulatory agencies in evaluating the safety of chemicals to which animals may be exposed and in determining precautions or management practices for their use.

Plant Metabolism

A major goal of plant metabolism research is to develop basic information about the behavior and fate of pesticides in plants. In these studies, scientists are investigating what happens to such pesticides as herbicides, fungicides, nematocides, and insecticides when they are sprayed directly on leaf surfaces or when they are absorbed by roots from treated soils.

Plant physiologists investigate differences in the ability of plant species and tissues to degrade pesticides. They also study the effects of pesticides and their degradation products on basic physiological processes necessary for normal plant growth and development.

Analytical and organic chemists isolate and characterize the metabolic products formed from pesticides by plants. The identification of these products often requires many complex analyses including the synthesis of radioactive pesticides and their metabolic products.

Biochemists identify the enzyme systems responsible for the metabolism of pesticides and formulating agents and study the mechanisms and pathways of pesticide degradation. They also examine possible interactions between different pesticides by investigating the effects of one pesticide on the metabolic fate of another when both chemicals are applied to the same plant during the growing season.

With the knowledge gained from these studies, scientists provide information needed to determine the safety of food and feed products treated with pesticides. The information also is used to assess any possible detrimental effects of "terminal" plant residues in the environment.

Insect Physiology and Metabolism

Unique characteristics of insects that might be exploited in suppression and control programs are under study by insect physiologists and biochemists. Their emphasis is on a better understanding of the function of enzymes and hormones that control certain life processes specific to insects.

Ability of insects to enter diapause, a period during which activity and growth are suspended, permits them to overwinter under conditions that would otherwise be unfavorable for survival. By determining how the insect's physiological mechanism responds to photoperiod (daylength) and induces diapause, scientists hope to develop means of preventing or prematurely breaking

diapause to inhibit insect survival. A genetic approach to the same objective is by breeding economically important insects that are unable to enter diapause.

Other studies center on such life processes as molting, or shedding of the exoskeleton, which allows insects to grow; formation of the thin, waxy layer of the epicuticle, which protects the insect from death by dessication; and the hormonal system that controls egg development. Once these insect-specific processes are

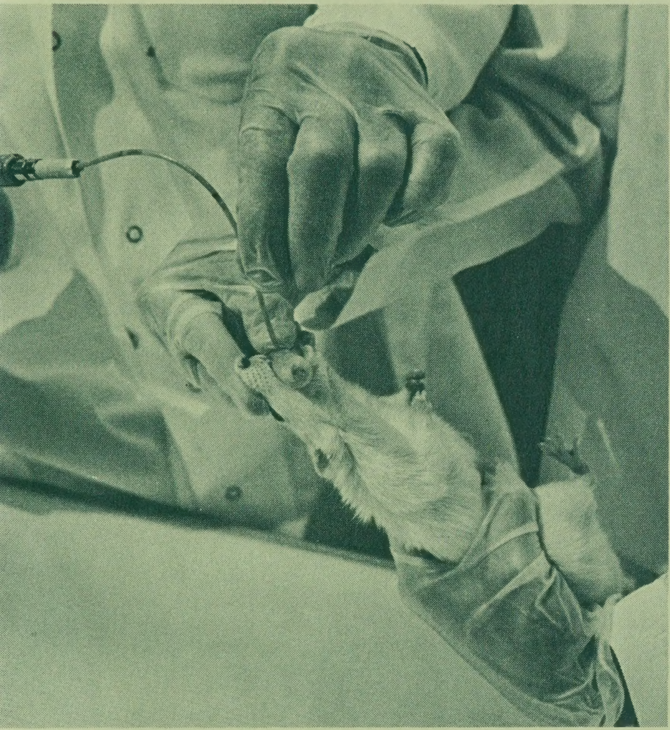
Agricultural chemicals pass through plastic tube into rat's stomach for tests.

Separating male from female houseflies for study of mutant genetics.

Sorghum seedlings grow in water containing nutrients and radio-active herbicide.

understood, researchers may have the means for interrupting them and causing the insect to die.

Researchers are also investigating the effects of laboratory rearing on insects to be released in control programs — insects carrying lethal traits or sterilized by exposure to radiation or chemicals. In addition, scientists are identifying biochemical markers for distinguishing insects with different inherited characteristics — useful in monitoring effectiveness of insects released in control programs.



Insect Genetics and Radiation Biology

Autocidal methods of insect control — use of a species to control the same species — are potentially useful in pest-management systems. Mass-reared insects that are sterile or carry lethal genes, if introduced when the native population has been brought to a low level by natural or other means, can effectively suppress or control when the released insects are competitive in nature.

Scientists have demonstrated that release of insects sterilized by exposure to radiation is effective in the control of some species. For example, this approach has been used to eradicate the screwworm fly from the Southeastern United States and to control the pest in the Southwest. Other such insects as the medfly, onion fly, and mosquito have been controlled in smaller field tests by the sterility technique.

Other methods are being studied to use special genetic strains of insects to reduce field populations of the same species. Some possibilities are:

- Releasing sterile hybrid insects produced from crossing two closely related strains.
- Releasing insects partially sterilized with radiation or chemicals that will transmit semisterility to some of their progeny.
- Releasing strains that produce only male or female progeny.
- Using strains with conditional lethal genes that are expressed only at specific temperatures.
- Replacing the natural population of disease transmitting insects with special strains that are unable to transmit disease.
- Introducing genes into the native population that will make the population easier to control or more sensitive to environmental changes that reduce their numbers.

Some pests being investigated for their suitability for suppression by autocidal methods are the cabbage looper, corn earworm, codling moth, boll weevil, tobacco budworm, house fly, stable fly, pink bollworm, and cotton bollworm — all severe and economically damaging pests of agriculture.

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